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8. A Brief Study on Digital Textile Printing

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Abstract:

DTP (Digital Textile Printing) is capable of producing an infinite variety of colors, yet it may be challenging to use pastels. It is expected that the image quality would be on par with rotary screen printing. The digital technologies give an unparalleled level of picture complexity, which raises the bar for what is expected. It's possible that DTP will help pattern design for clothes and home textiles seem more attractive. However, there are several limitations associated with the usage of DTP. Additionally, the use of traditional printing methods imposes some limitations. As a result of the rapid improvements in technology that are taking place in today's world, DTP is always growing. These improvements are not yet finished being implemented. It is possible that investors may find it difficult to decide at this time. It is necessary to have a sufficient amount of knowledge and experience in order to invest in DTP technology. Investing in DTP technology is something that should only be done after gathering the necessary information and conducting feasibility studies. Because this page examines DTP technology from a wide perspective, our goal is to provide assistance to those who are doing research on the topic. This paper studies the concept of digital textile printing. Also, study the evaluation of textile DTP, including the analysis of innovations and the importance of Digital Textile printing.

Keywords: Digital, Textile, Traditional, Inkjet, Fabric.

8.1 Introduction:

These days, markets are always shifting, and the only way for manufacturers to stay in business is to adapt to the requirements of their clients. Customers in the textile sector anticipate a diverse selection of patterns and hues. However, existing printing technologies are unable to meet the increased requirements, thus printers are exploring innovative methods to meet the expectations of customers without increasing their operational costs or the amount of waste they generate. Because it was originally created for printing on paper, inkjet printing technology is increasingly being employed for printing on textiles because it meets the demands of the expanding textile industry.

8.2 Textile Printing:

Textile printing is a method of decorating textile textiles by applying pigments, dyes, or other materials in the shape of patterns using different techniques. The four basic ways of printing are block, roller, screen, and heat transfer printing. In each of these processes, applying the color, which is often a thicker paste, is next fixed by steaming or heating, and finally the color is removed by washing.[1]

What Is Digital Textile Printing:

DTP uses inkjet to print colorants onto the cloth. Direct-to-garment (DTG) printing is common. It is printing on textiles and clothing using specialized inkjet technology.[2] The international study that Info Trends and Fespa conducted found that the application of wide-format DTP to textiles is the one that is expanding at the quickest rate. Ninety-three percent of printers asked said that they anticipate seeing development in this industry. According to Xennia, the key market drivers for a firm that makes digital printers to migrate towards DTP are the requirement for economically viable small print runs, quick and frequent design changes, a rise in the desire for personalization, and an increase in the number of specialized items. In addition, the amount of money made from selling digitally printed cloth is rising gradually, and it is anticipated that this trend will continue in the years to come.[3]

Printing on Textiles Using Digital Technologies:

The rise of digital technology has impacted every facet of modern life. Naturally, textile printing has also adopted new technologies to meet its requirements, with the necessity for quicker and more affordable samples serving as the primary motivator. Printing done digitally is a relatively recent development in the realm of technology. It was designed for use in printing on paper in its early stages. In 1867, Lord Kelvin was the first person to be granted a patent for an inkjet printing technique.[4]

"In addition, the first use of jet printing machines on textile fibres occurred in the early 1970s; however, this use was confined to the carpet industry owing to the machines' inadequate pattern definition at the time. The production of digital laser versions of electrophotography transfers for T-shirts and other clothes and accessories became conceivable in the 1980s".[5]

The term "digital printing" refers to a collection of techniques that can transport a picture from its digital form to the surface being printed (or substrate). Because various target

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[1] Adams, J. M., Faux, D. D., &Rieber, L. J. (1996). Printing Technology (4th ed.), Albany, NY, Delmar Publishers.
[2] Hakola, E. &Oittinen, P. (2009). Principles of digital printing, In Oittinen, Saarelma(2nd ed.).
[3] Ujiie, H. .Digital printing of textiles. Boca Raton: CRC Press.
[4] Prust, Z. A. (2003). Graphic communications: The printed image, The Goodheart- Willcox Company; 4th edition.
[5] https://en.m.wikipedia.org/wiki/Digital_textile_printing

surfaces each possess their unique properties, not every printing process can be used for every substrate. Continuous inkjet technology, piezoelectric inkjet technology, and thermal drop-on-demand inkjet technology are shown in Figure 8.1 as the three different ways that inkjet technology may be implemented.

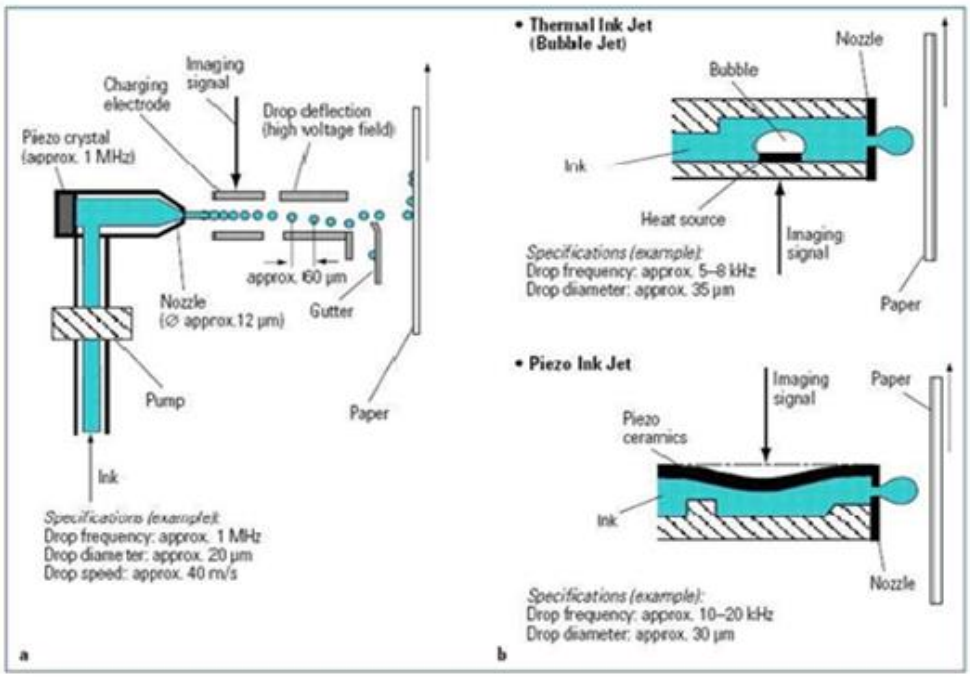

Figure 8.1: Ink jet technologies:(a) continuous ink jet, (b) drop on-demand ink jet.

Inkjet printing with piezoelectric drop on demand (DOD) technology is the most common method for printing fabrics. A pattern is created by projecting a stream of ink droplets onto a material using this method. Utilizing the electromagnetic field improves the placement precision of droplets[6]. There are further options for the inkjet technique, including thermal DOD printing and continuous flow printing. However, the piezoelectric DOD method is often used for DTP on textiles[7]. Printing on textile substrates also necessitates certain modifications to standard printing methods in order to adhere the ink to the intended surface. "The need stems from the fact that fabric must be resistant to washing and weather exposure. Thus, there are two methods for DTP on textiles: direct inkjet printing and indirect inkjet heat-transfer printing".[8]

8.3 Textile Inkjet Printing:

[6] STFI- Mottling (2012).An Accurate Way of Quantifying Print Density Variations.
[7] https://en.m.wikipedia.org/wiki/Digital_textile_printing
[8] Hakola, E. &Oittinen, P. (2009). Principles of digital printing, In Oittinen, Saarelma(2nd ed.).

Inkjet printers employ two basic technologies: continuous and drop-on-demand.CIJ is the oldest technology. Its functioning is based on Rayleigh instability (Plateau-Rayleigh instability), which describes how surface tension effects a fluid stream's droplet size. It signifies that liquid may be broken into tiny droplets. Charged droplets travelling across an electromagnetic field may regulate the inkjet's orientation.[9] This printing method offers benefits. It is non-contact, and the printer can print on various substrate shapes. Printing using inkjet on fabrics is sustainable. Inkjet technology continues to advance. Printing textiles requires both print heads and colorants. Increasing the number and frequency of print head nozzles enhances the printing speed of an inkjet printer. Smaller droplets, grayscale, and a wider color range enhance image quality.

8.3.1 DTP needs:

Consumers seldom care about the technology utilized to make a product. End-users care most about product quality and pricing.[10] This list outlines user needs. DTP has color difficulties. DTP can generate any number of hues, but pastels may be difficult to employ. Image quality should be as excellent as rotary screen printing. Digital technologies provide unprecedented image complexity, raising expectations.[11] Due to the exposure of most fabrics to abrasion, light, water, and chemicals, customers expect rapid screen printing. Consumers want lower prices. The price-to-quality ratio for samples should be comparable to traditional screen printing or lower. Interdependent needs: Cost is the major driver. Optimizing this balance determines the technological needs of end users. DTP relies on:

- Ink system
- Print head

Various fabrics need different techniques. Pre- and post-treatment of surfaces may increase picture quality, whereas dirt can produce printing artefacts. Movement of the fabric affects dot registration and results in bands or stitch lines. DTP should streamline the sample procedure, reduce sampling and marketing times for smaller projects, and decrease sampling costs.

8.4 Fabric Substrate in Digital Textile Printing:

Although textile printing inherited inkjet technology from paper printing, there are considerable distinctions. Different target surfaces have different purposes. While the paper is designed for high-quality printing, it is seldom exposed to elements. Fabrics are created for certain uses. DTP must solve quality and durability difficulties underexposure. For paper printing, target surfaces may be coloured or water-resistant. Each kind of cloth has unique printing qualities related to composition, texture, fibre structure, and water resistance. Textiles are more absorbent than paper, needing more ink. Textiles provide another fundamental challenge as a printing substrate: fabric handling. Textiles are stretchy, porous,

[9] Thompson, B. (1998). Printing Materials: Science and Technology, Pira International.
[10] Helpful facts about paper (2004). Xerox Corporation.
[11] https://en.m.wikipedia.org/wiki/Digital_textile_printing

and textured. These qualities vary by cloth type. In order to print fabrics, printing equipment must be versatile.[12] Textile printing may expose surface components. The printing should not influence the fabric's softness or "touch" qualities, which would reduce its usefulness. In certain applications, many components must be assembled, requiring reliable outcomes.[13]

8.4.1 Fabric Printing:

Inkjet printing for textiles encompasses a variety of pattern-transfer processes. Direct and transfer printing are different. The design is imprinted on transfer paper and then heat-transferred to the cloth in transfer media printing. This method requires no substrate preparation, although the results differ from direct printing. The design is not linked to the cloth but plastic or an equivalent layer.[14] Durability is lower than with direct printing. Direct printing uses pigment and dye. The simpler is pigment printing. Print, dry, and bake. Early inkjet printers used the thermal DOD concept, making adaptation difficult. Because it is cheaper, it is used to print cotton.[15] Screen printing uses reactive dye printing. “Print, dry, steam, wash-off, and dry are the five steps”.[16]

Reactive dye includes thickeners for screen printing. "All-in" inks are problematic for jet-ink printing. Issues include: All-in-one inks are not storage-friendly. Chemicals may destabilize ink. Long-term exposure to ink chemicals may harm printing heads. Printing requires low viscosity ink, but picture printing requires greater viscosity. Existing concerns with all-in-one inks for jet printing and the advantages of utilizing particular chemicals for end-product quality have led to the two-phased printing technique. This technique pre-treats the substrate with thickeners. Second, pure dyes are used to create a pattern.[17] A two-phased printing method improves print quality and, if needed, customizes chemical solutions for the substrate fibre type. It also complicates the printing process since a printer needs pre-treat the substrate before applying the dye, increasing equipment complexity and expense.

8.4.2 Ink Pigments:

Pigmented ink requires numerous materials for pigment printing. A pigment dispersion, a binder, a medium to transport additional components, a co-solvent, surfactants, humectants, an antifoam agent, a viscosity control agent, a penetrant, and a biocide are the typical components of an ink composition. Pigment dispersion is a coloured substance that may be divided into minute particles. Dispersion material does not bond to the textile substrate and needs a binder. The ink contains a binder. Binder solution protects images.[18] Water is the transporting medium for water-based pigment ink (or solvent). “polyvinyl chloride (PVC)” is another solid ink used for digital textile printing. Each system has pros and cons. PVC-

[12] White, I. C. (1975). The Print Quality Index - A Management Tool, TAGAProceedings, pp. 259 - 269.
[13] https://en.m.wikipedia.org/wiki/Digital_textile_printing
[14] https://textilelearner.blogspot.com/03/digital-printing-textiles.html?m=1
[15] Hakola, E. &Oittinen, P. (2009). Principles of digital printing, In Oittinen, Saarelma(2nd ed.).
[16] https://textilelearner.blogspot.com/03/digital-printing-textiles.html?m=1
[17] https://www.britannica.com
[18] Heilmann, J. &Antikainen, H. (2009). Inkjet technologies, Finland: VTT.

based ink is simpler to bake (or cure), but re-heating may re-bind.[19] PVC printing costs more than aquatic inks. Substrate type affects print quality. The ink contains co-solvents and humectants. Co-solvents help dissolve other compounds in water. Humectants prevent ink from drying in idle and active printer nozzles.

Viscosity agent affects ink's physical characteristics. Viscosity affects how printing ink behaves. Surfactants affect ink's surface tension. This parameter influences the interaction between ink and nozzle, bleed, and dot quality. Parameters have an effect on picture quality. Penetrant aids ink carriers in penetrating substrates.

De-foaming chemicals prevent ink foaming. Biocides inhibit bacterial development, hence prolonging the shelf life of ink. Ink may include all of these components, however this is not usually the case. Some chemical combinations are multifunctional. Due to chemical incompatibility, combining the components might be difficult. Complex pigmented ink offers advantages. First, substrate pre-processing is optional. However, it may be done. Post-processing involves dry heat.

8.5 Benefits of Digital Textile Printing:

In order to grasp the advantages of digital textile printing, it is vital to identify the challenges that conventional screen printing presents. DTP is eco-friendly and cost-effective for the textile sector.[20] DTP allows printing without rotating screens. Traditional printing is the only cost-effective solution for high quantities and sizes. DTP is an option for samples and low-volume prints (under 1,000 m2). It covers rotary screen printing difficulties. DTP removes screens since patterns are printed directly on the substrate.[21] DTP avoids most complications created by screens.

Second, designing and updating a pattern is as straightforward as editing a computer picture and printing it. Time is saved. Creating a sample using a rotating screen would take days. DTP shortens this time. It saves time, money, and energy. Third, automation reduces labour costs, making manufacturing locations less relevant. Eco-friendly inkjet printing. Traditional printing uses 30% less water and 45% less power.[22]

Typical rotary screen printers run “9,000-18,000” meters. Most of it has 2-10% mistakes (or a second run). Screens cause most print failures. “Stick-ins, misfits, scrimps, and wicking is components of rotary screen printing”.[23] They can be reduced but not eradicated. Digital textile printing's benefits:

- Eliminates rotary screen difficulties.

[19] White, I. C. (1975). The Print Quality Index - A Management Tool, TAGA Proceedings, pp. 259 - 269.
[20] Textilelearner.blogspot.com
[21] https://study.com/academy/lesson/digital-textile-printing-machine-process.html
[22] Textileschook.com
[23] Textileschook.com

- Speeds up design introduction and change.
- Reduces new-design expenses.
- Reduces energy, water, and material use.
- Devalues low-cost manufacturing locations.
- Reduces pollution.

DTP removes screens and simplifies printing. It provides textile printers with an eco-friendly choice.

8.6 DTP Problems:

DTP is a novel technique with flaws. DTP is used largely for sampling, according to Brooks Tippett. This technology's flaws may not be as obvious as with conventional methods. "Banding" is a major concern. This phrase comes from paper printing. It is how most digital printers make patterns on surfaces. A printing head usually moves in a straight line above the target. Line by line, the substrate is pulled across the printing head path. Perfect mechanical alignment and substrate movement control are required for a continuous picture. Narrow unprinted strips may appear otherwise. [15]"Perfect" alignment is subjective for manually-operated mechanical equipment. Replicated printing heads or numerous passes eliminate banding. The textile's three-dimensional structure reduces the "banding" issue. Printing head nozzle misfires or clogs are another similar issue. Both situations have missing or partly coloured pixels.[24]

Modern printers' redundant nozzles lessen the problem. It is analogous to "stick-in" in rotary screen printing, but it is readily minimized with digital textile printing.[25] Fabric handling is another DTP mechanical failure area. Fabric can move, unlike paper. It may stretch or wrinkle unevenly. Since the printing head must be near the cloth to make a perfect design, it may touch wrinkled fabric. This may cause pattern deformation or printing head damage. DTP has developed in fabric management during printing. Keep the substrate stationary. DTP has generated new color challenges.[26] As an inherent aspect of digital imaging, DTP must use dithering to achieve particular hues. This strategy may fail for certain colors. Tippett says it is one of the greatest difficulties for DTP in textiles. Repetitive colors are another problem. A printer cannot print identical colors. Side-to-side printing, necessary for bigger prints, is affected. Color repetition is caused by ink quality, manufacturer and cartridge variances, and substrate qualities. DTP is only cheap for small runs since it utilizes costly inks and is slow. The following are DTP issues:

- DTP bands.
- Print head contact with a cloth may distort images or harm printers.
- Problems with halftones.
- Side-by-side printing has difficulties with color repetition.
- Textile printers employ pricey inks.

[24] https://digitaltextilereview.com/?p=814
[25] Hakola, E. &Oittinen, P. (2009). Principles of digital printing, In Oittinen, Saarelma(2nd ed.).
[26] https://en.m.wikipedia.org/wiki/Dye-sublimation_printer

- Textile printers are slow.
- DTP is the cheapest in the short run.
- New print heads and dyes would address most DTP concerns.
- Business growth

The startup will first provide Internet service for light overhead textile printing. Because hosting one's own or rented equipment is expensive, the initial phase of business deployment focuses on service logistics.[27] The digital printer will split the earnings. First-stage goals are to build a client base and assess company requirements in the target market. With these data, you can anticipate the second stage of company growth. The second step involves Finnish printing. It eliminates outsourcing and shipping expenses. Storage, office space, equipment upkeep, and personnel will increase. The second step is only possible if there is a consistent demand for the service. Increasing orders reduce material and manufacturing expenses. Growth will necessitate some product marketing expenditures.[28] Local printing facilities may increase material costs since FabDigital will need to stock textiles for quicker delivery. Possible rivals and a small local market impede company expansion. If the firm succeeds, local competitors will likely emerge. These services target the same consumer base, which might restrict expansion in a narrow market. Even without competition, the non-industrial textile DTP market is small. Growing will involve entering neighboring markets. On-demand consulting and design services will be supplied, but growth is impossible to forecast.[29]

8.7 Conclusion:

DTP meets mass customization market trends. It is a good sample-production technique. Printing speed is a major technological commercialization challenge. Printing speeds are being improved. This business is developing quickly, and new developments make printing easier and faster. Textile printing acquired inkjet from paper printing, although there are differences. Surfaces have varied roles. High-quality printing paper is seldom exposed to the outdoors. Fabrics have certain purposes. DTP must overcome quality and durability issues.[30]

Paper printing targets may be coloured or water-resistant. Each fabric's composition, texture, fibre structure, and water resistance affect its printing capabilities. Fabrics absorb more ink than paper. Fabric handling is another printing problem with textiles. Stretchy, porous, textured fabrics. Cloth type affects these properties. Fabric printing requires diverse equipment. Textile printing reveals surface components. Finishing fabrics reduce exposure. Printing should not decrease the fabric's softness or "touch" properties. In certain applications, assembling multiple components requires reliability.

[27] Heidelbeg Heritage (2005). A tradition of innovation, Heidelberg Druckmaschinen- AG.
[28] https://en.m.wikipedia.org/wiki/Dye-sublimation_printer
[29] Harrison, V. (2003). Optical Properties of Paper, In Formation and Structure of Paper, F. Bolam Ed., vol. 1, pp. 467 – 485.
[30] Hakola, E. &Oittinen, P. (2009). Principles of digital printing, In Oittinen, Saarelma(2nd ed.).

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1. Adams, J. M., Faux, D. D., & Rieber, L. J. (1996). Printing Technology (4th ed.), Albany, NY, Delmar Publishers.
2. Thompson, B. (1998). Printing Materials: Science and Technology, Pira International.
3. https://en.m.wikipedia.org/wiki/Digital_textile_printing
4. White, I. C. (1975). The Print Quality Index - A Management Tool, TAGA Proceedings, pp. 259 - 269.
5. https://en.m.wikipedia.org/wiki/Digital_textile_printing
6. https://digitaltextilereview.com/?p=814
7. Hakola, E. & Oittinen, P. (2009). Principles of digital printing, In Oittinen, Saarelma (2nd ed.).